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SCIENTIFIC COMPUTER DIVISION

Report No. RRC-38

February, 1967

RIDE CHARACTERISTICS OF
LIGHTWEIGHT TRACKED VEHICLES

by

S. F. Heal

J. C. Prasiloski

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RRC-38

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February 1967

U. S. Army Tank Automotive Command
Mobility Systems Laboratory
Scientific Computer Division

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ABSTRACT

The ride characteristics of a series of lightweight track vehicles were studied on the analog computer. The maximum tolerable speeds were obtained for five vehicles: The Weasel, Polecat, Thiokol Spryte, Westerasmaskiner Snow-Trac, and a tractor traveling over a hard meadow terrain.

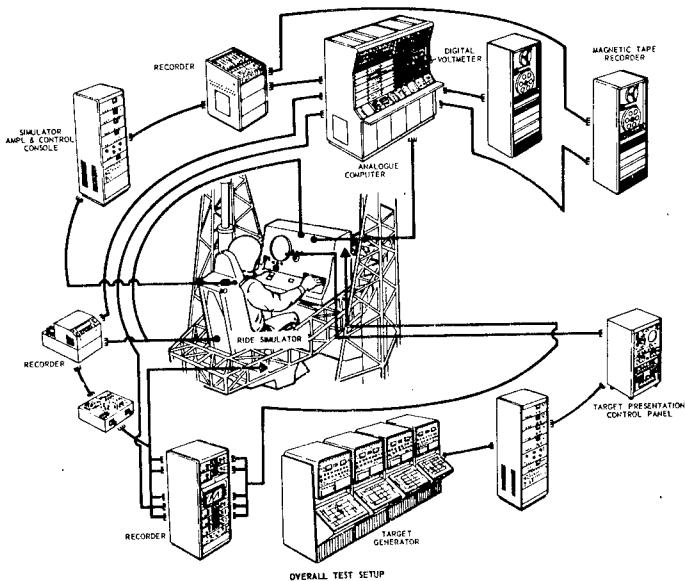
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INTRODUCTION

The ride analysis for five existing lightweight tracked vehicles was conducted to illustrate and correlate the method of absorbed power for determining maximum tolerable speed over a hard meadow terrain.

The study was performed using analog computer simulation techniques to obtain the vehicle motions. The motions were then reproduced into the ride simulator and into the absorbed power circuitry to obtain the limiting maximum vehicle speed by both the ride simulator and the absorbed power techniques. The resultant data was then compared to maximum vehicle speeds measured over the actual test course.



Ride Simulator, Fig. 1

DISCUSSION

Analytical prediction of cross country speeds for concept vehicles has been performed by the Army Tank-Automotive Center for several years. The method employed describes the dynamic characteristics of a vehicle on an analog computer.^{1,2} The calculated vehicle vibrations are then applied as the input function to a ride simulator for subjective evaluation by experienced vehicle test drivers.

Recently, a new purely analytical method was developed, "Absorbed Power".³ Absorbed power is the rate at which energy is absorbed by a human body while being subjected to a vibration. Extensive testing has correlated absorbed power with subjective response as a measure of vibration severity from barely perceptible levels to maximum tolerable limits. When transfer function techniques are applied, absorbed power can be measured from only an acceleration without the use of a test subject.

The analog computer/ride simulator technique and absorbed power method has been correlated with field test data for a heavy tracked vehicle. However, the technique has not been compared with field tests of lightweight track vehicles of the Polecat, Weasel, Snow-Trac, Spryte and tractor class. For additional correlation, a simulation study was performed of these vehicles traversing a known terrain and comparing the results to field test data. Because of the magnitude of instrumentation required for measuring actual vehicle motion, the maximum tolerable speed of the drivers' position was the basis for the correlation study. Each of the five vehicles were driven over the course at the maximum speed attainable by the driver without severe discomfort or loss of control. This velocity was then considered the maximum tolerable limit.

The analytical experiment was conducted by obtaining the required vehicle data and a profile of the terrain used. The data is shown in Appendices A and B, respectively.⁴ Only pitch and vertical motions were studied on the computer for the simulated speeds in Table I.

TABLE I

<u>Vehicle</u>	<u>Vehicle Speed (MPH)</u>
Snow-Trac	5, 7, 10, 15, 20, 25, 30
Spryte	5, 7, 10, 15, 20, 25, 30
Weasel	5, 7, 10, 12.5, 15, 20, 25
Polecat	5, 7, 10, 15, 20, 25
Tractor	1, 2, 4, 5, 7, 10

The simulated ride motions at each of these speeds were recorded on magnetic tape for subsequent use as input to the "absorbed power" circuitry and the ride simulator.

The ride simulator is capable of four degrees of motion, pitch, roll, bounce and yaw. It is hydraulically driven and electronically controlled. Each of the motions may be used individually or simultaneously. Random motion inputs to the simulator may be obtained directly from the analog computer or by reproducing information previously recorded on magnetic tape. Details of the simulators capabilities are given below:

<u>MOTION</u>	<u>MAXIMUM TOTAL TRAVEL</u>	<u>MAXIMUM FREQUENCY, Hz</u>
Bounce	2 feet	60
Roll	30 degrees	60
Pitch	30 degrees	60
Yaw	20 degrees	3

It has been established that a reasonable tolerable limit of human vibration for random, sinusoidal or other inputs to the absorbed power circuitry is six watts. The measurement may be made by measuring the absorbed power of a test subject or by calculating the absorbed power analytically through the use of a transfer function. The values of vehicle speed based on absorbed power derived from the method are compared in the summary with experimental measured values.

SUMMARY

The absorbed power for the vehicles studied was plotted in Figure 2. These results were then graphically interpolated for the maximum tolerable speed at the six watt reference level. A comparison of the field trial data and analytical method is shown in Table II.

TABLE II

<u>Vehicle</u>	<u>Analytical Prediction</u>	<u>Field Trial</u>
Snow-Trac	16.3	16.5 MPH
Spryte	15.2	15.7 MPH
Weasel	14.0	15.3 MPH
Polecat	11.0	13.6 MPH
Tractor	3.5	6.0 MPH

The correlation, as shown in the above table, was considered satisfactory. The large deviation in the tractor results were due to the limited definitive data on the rigid suspension characteristics. The details of the Polecat articulation joint were also not exact and, hence, greater simulation error was expected.

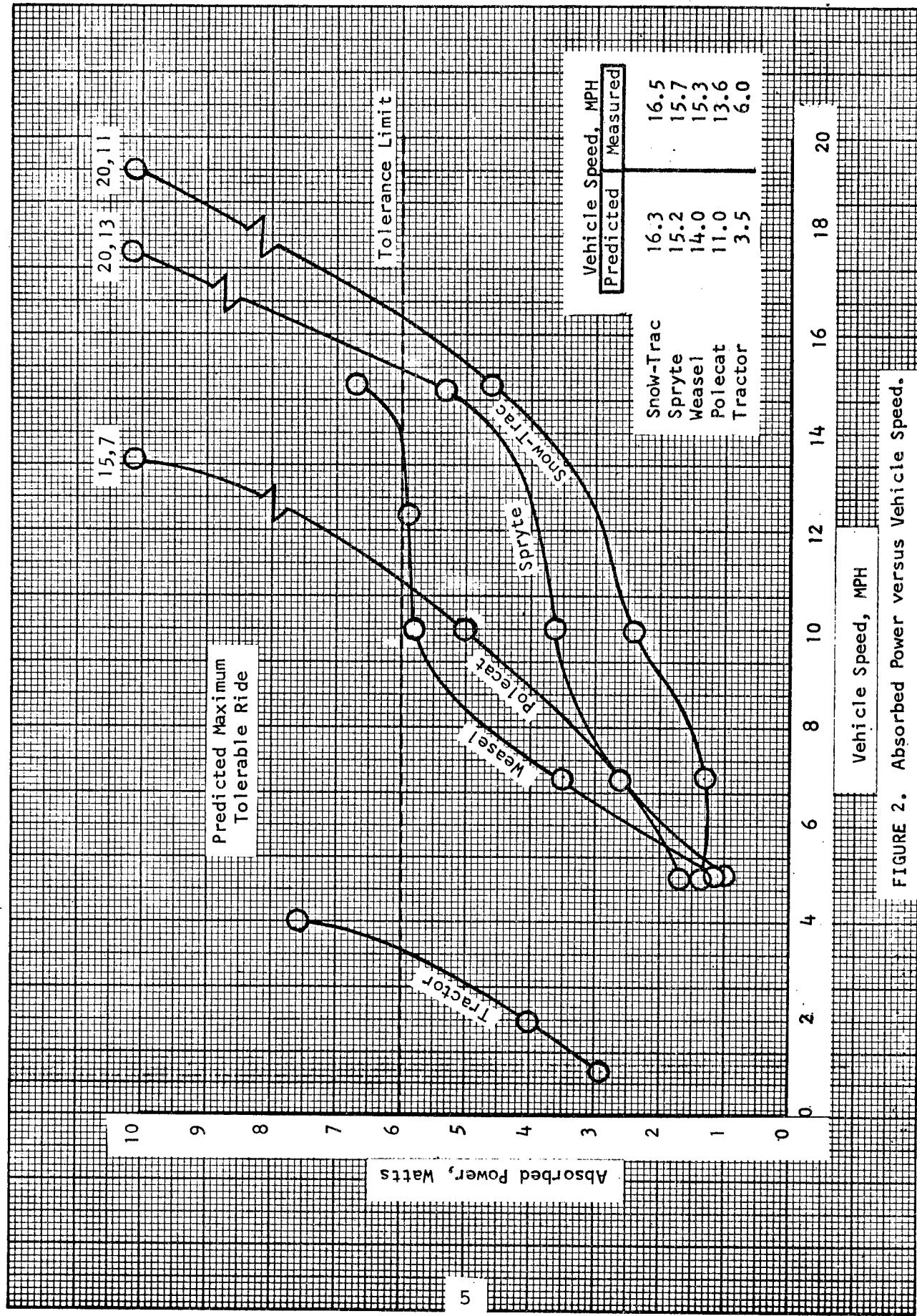


FIGURE 2. Absorbed Power versus Vehicle Speed.

Reference:

1. ATAC Report RR-38, "Suspension Analysis", S. F. Heal.
2. ATAC Report RR-44, "Generation of Road Profile for Vehicle Ride Simulations", M. Archambault and S. F. Heal.
3. ATAC Report RRC-28, "Theory of Human Vibration Response".
4. The vehicle data, terrain profile, and experimental speed test data were obtained from the Michigan Technological University under Contract No. DA-20-113-AMC-08571 (T).

APPENDIX A
Vehicle Data

SNOW-TRAC

SNOW-TRAC

Total Weight 3140 Lbs.
Sprung Weight 2877 Lbs.
Unsprung Weight 263 Lbs.
Sprung Pitch Moment of Inertia 1600 \$lug-Ft²
Distance from Ground to Center of Gravity 25 Inches
Shock Absorbers Data not available
Assume Vertical Damping Ratio of .2
Roadwheel Damping: Assume equal to .2 of critical
Idler Damping: Assume equal to .2 of critical
Vehicle Dimensions: See Figure 4.
Spring Rates: See Figures 5 and 6.
Bogie Moment of Inertias: Estimated.

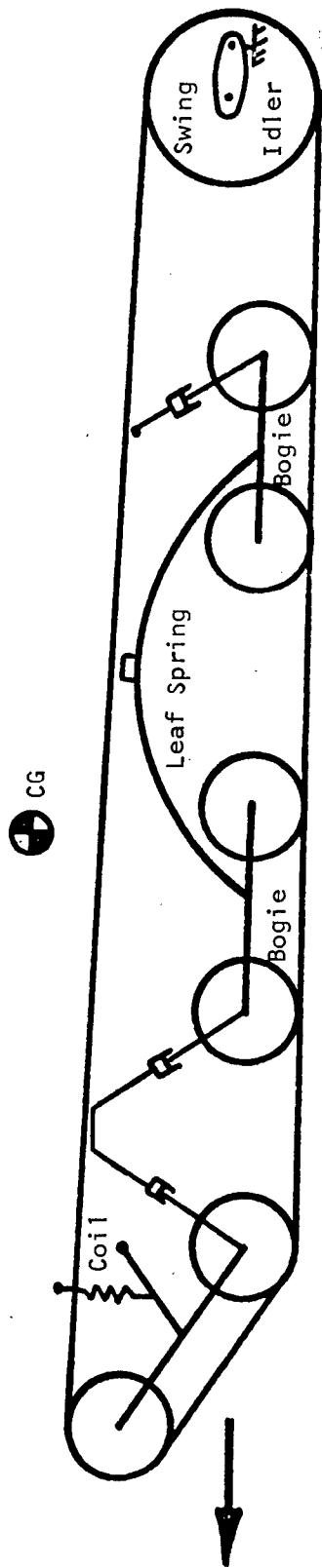


Fig. 3
SNOW-TRAC SUSPENSION CONFIGURATION

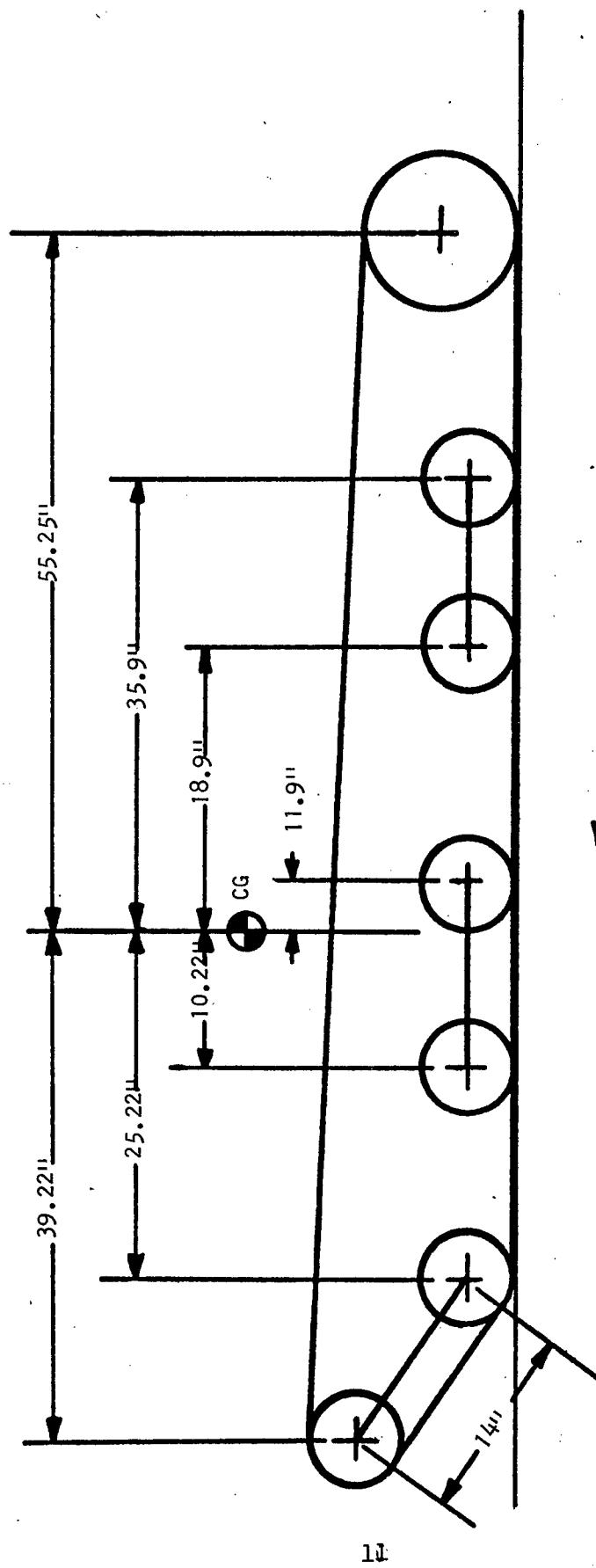


Fig. 4
SNOW-TRAC ROADWHEEL TO CG DIMENSIONS

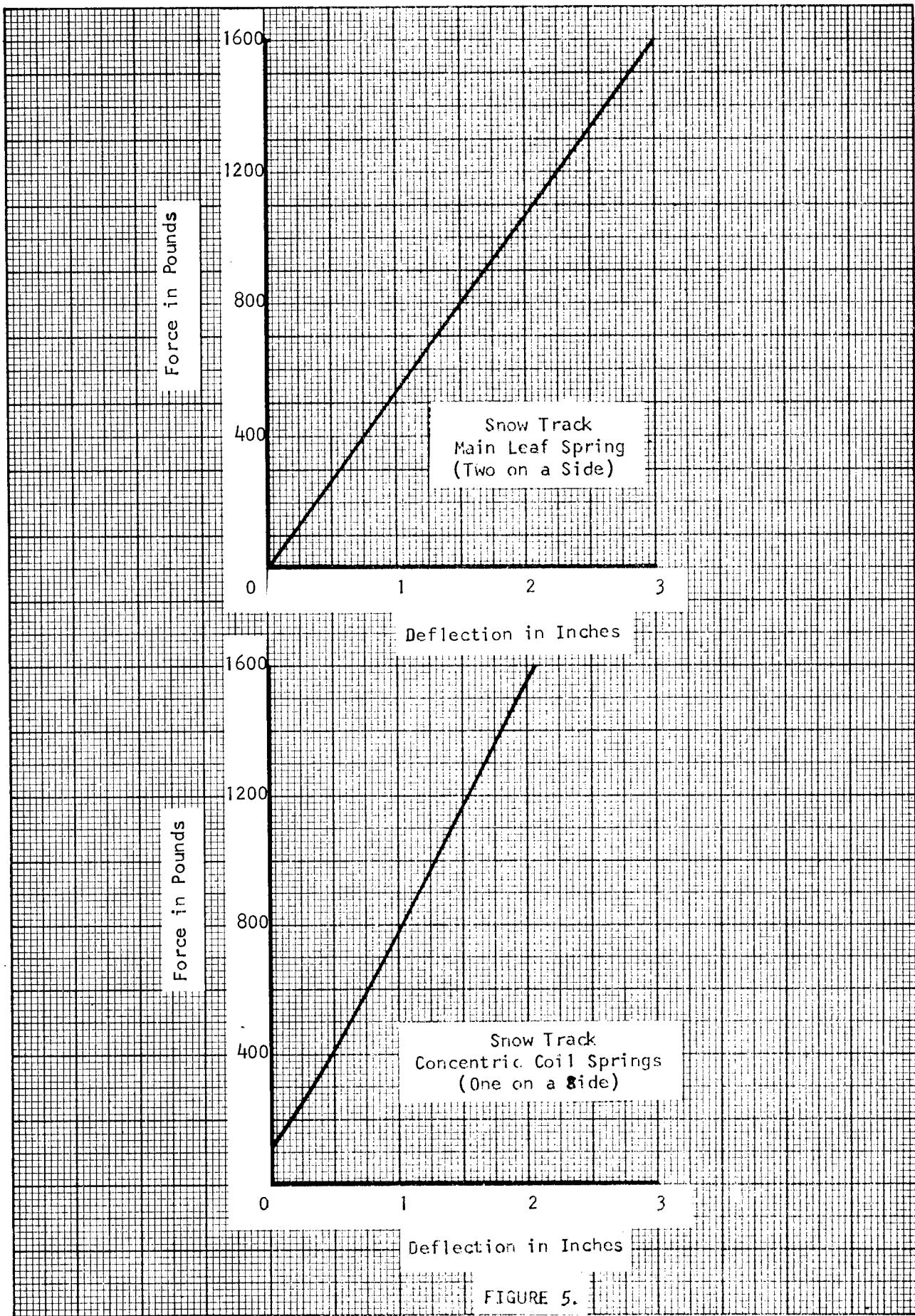


FIGURE 5.

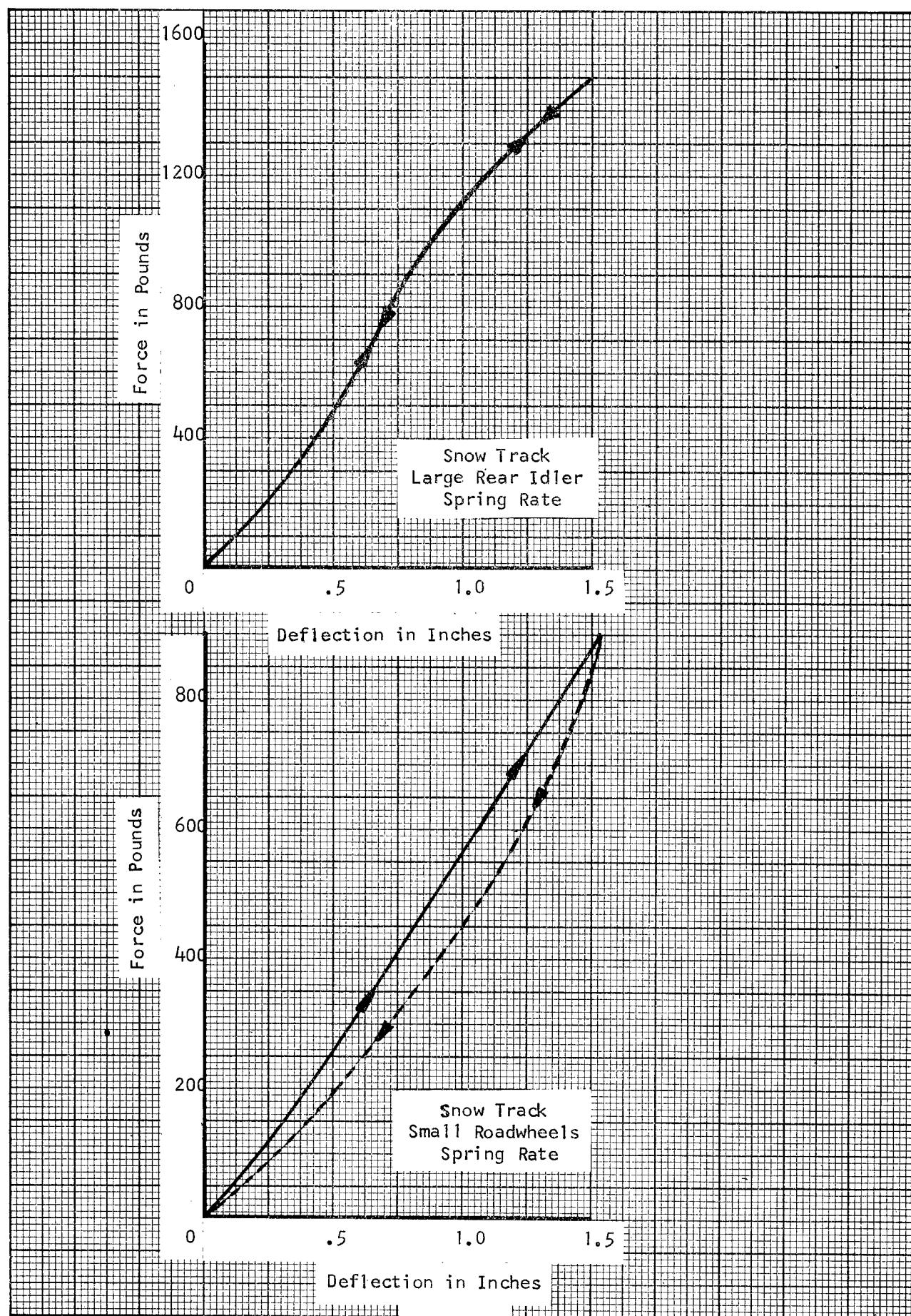


FIGURE 6.

SPRYTE

SPRYTE

Total Weight	3425 Lbs.
Sprung Weight	3016 Lbs.
Unsprung Weight	409 Lbs.
Sprung Pitch Moment of Inertia	1993 $\text{slug}\cdot\text{Ft}^2$
Distance from Ground to Center of Gravity	28 Inches
Shock Absorbers	None
Assume Vertical Damping Ratio of .2	
Roadwheel Damping: Assume equal to .1 of critical.	
Vehicle Dimensions - see Figure 7.	
Spring Rates - see Figures 8 and 9.	

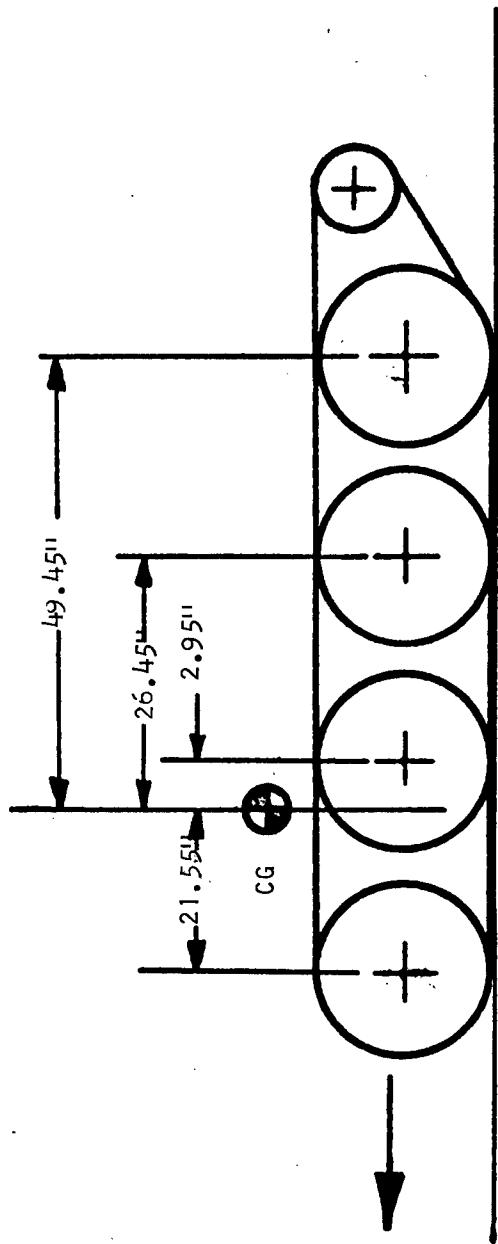
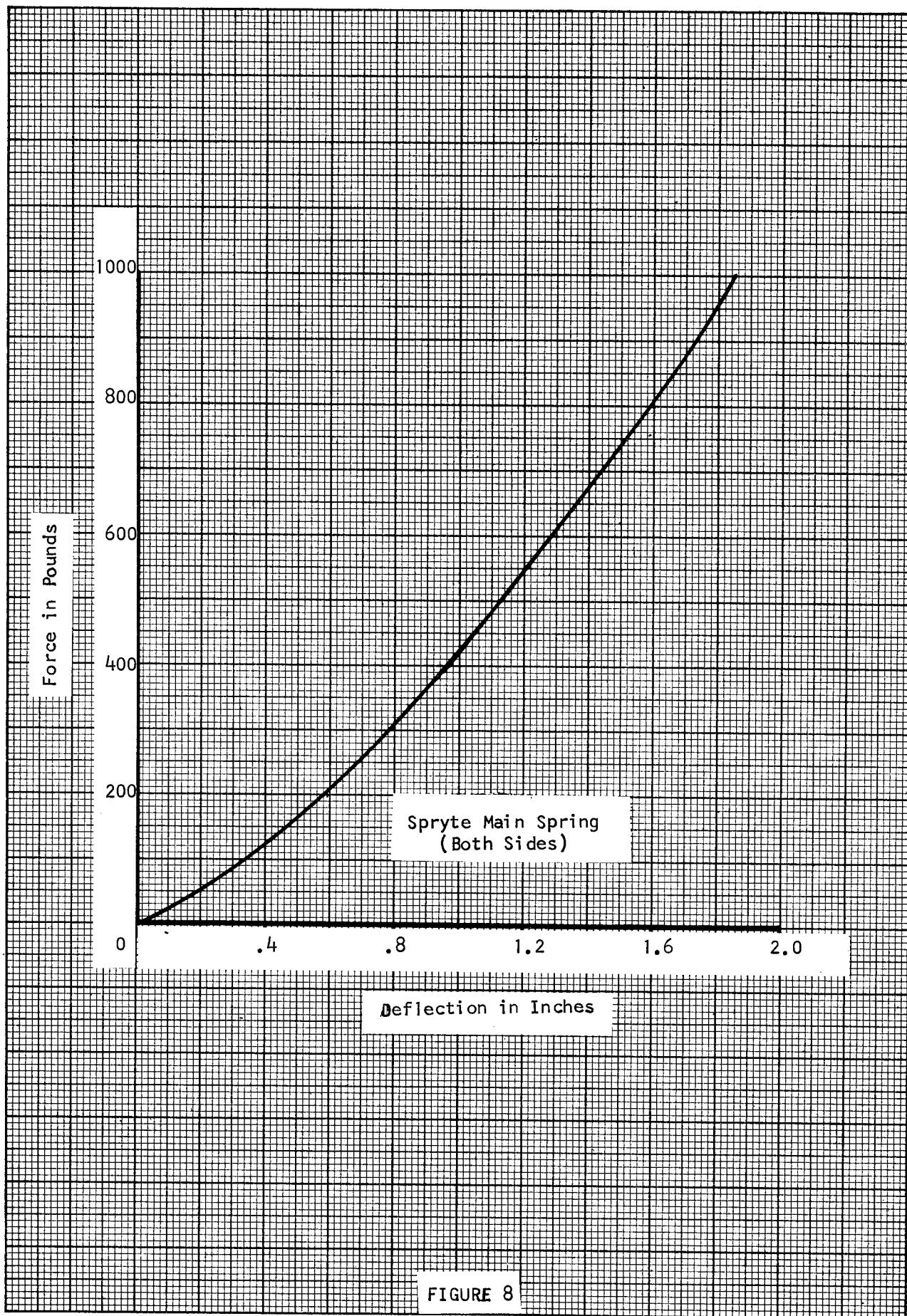


Fig. 7
SPRYTE ROADWHEEL TO CG DIMENSIONS

K*E 10 X 10 TO 1/2 INCH 46 1323
7 X 10 INCHES MADE IN U. S. A.
KEUFFEL & ESSER CO.



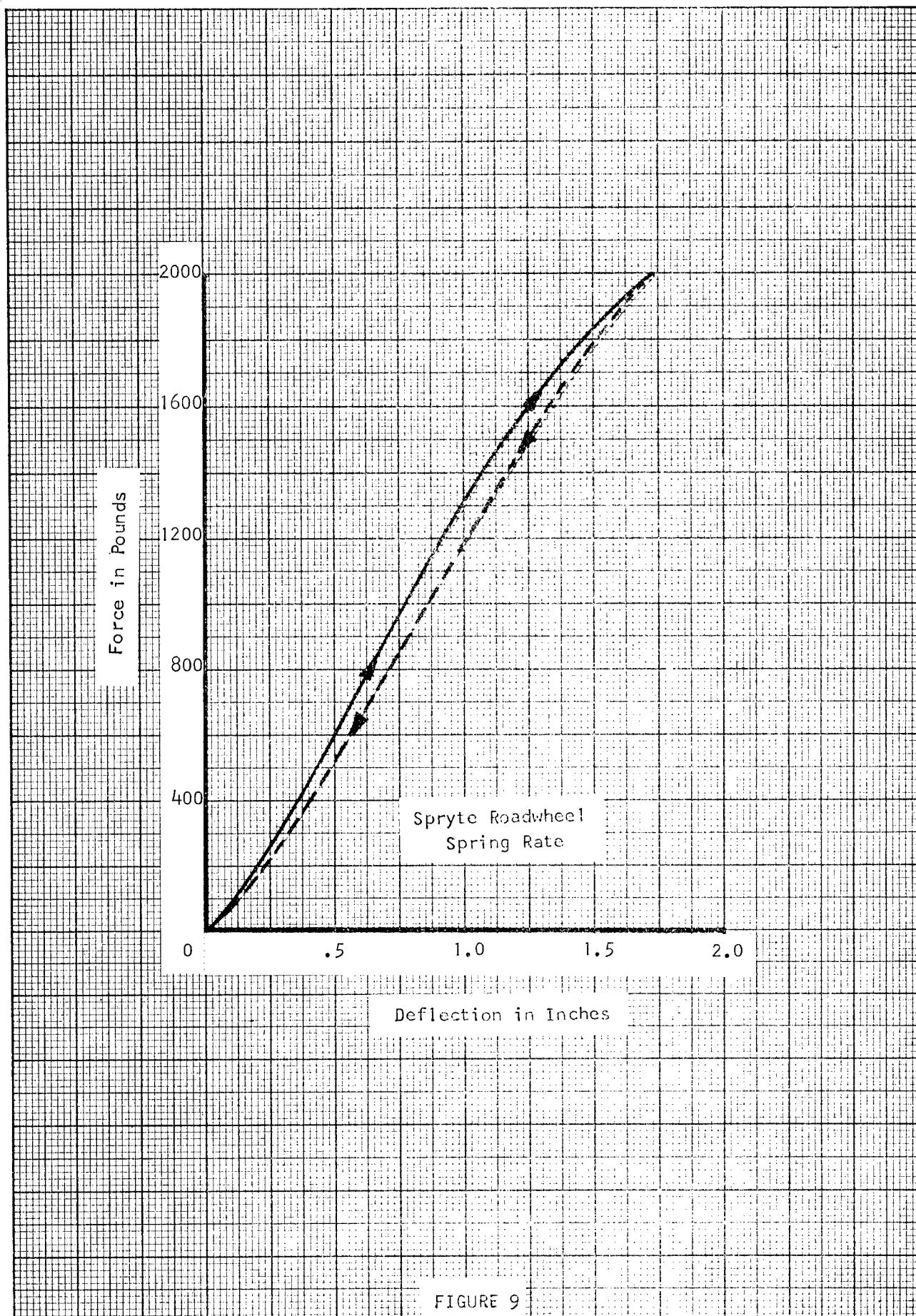


FIGURE 9

WEASEL

WEASEL

Total Weight 4740 Lbs.

Sprung Weight 4168 Lbs.

Unsprung Weight 572 Lbs.

Sprung Pitch Moment of Inertia 3200 \$lug-Ft²

Distance from Ground to Center of Gravity 25.6 Inches

Shock Absorbers Data not available
Assume vertical damping ratio of .3

Roadwheel Damping: Assume equal to .1 of critical.

Vehicle dimensions: See Figures 10 and 11.

Spring Rates: See Figures 12 and 13.

Bogie Moment of Inertias: Estimated.

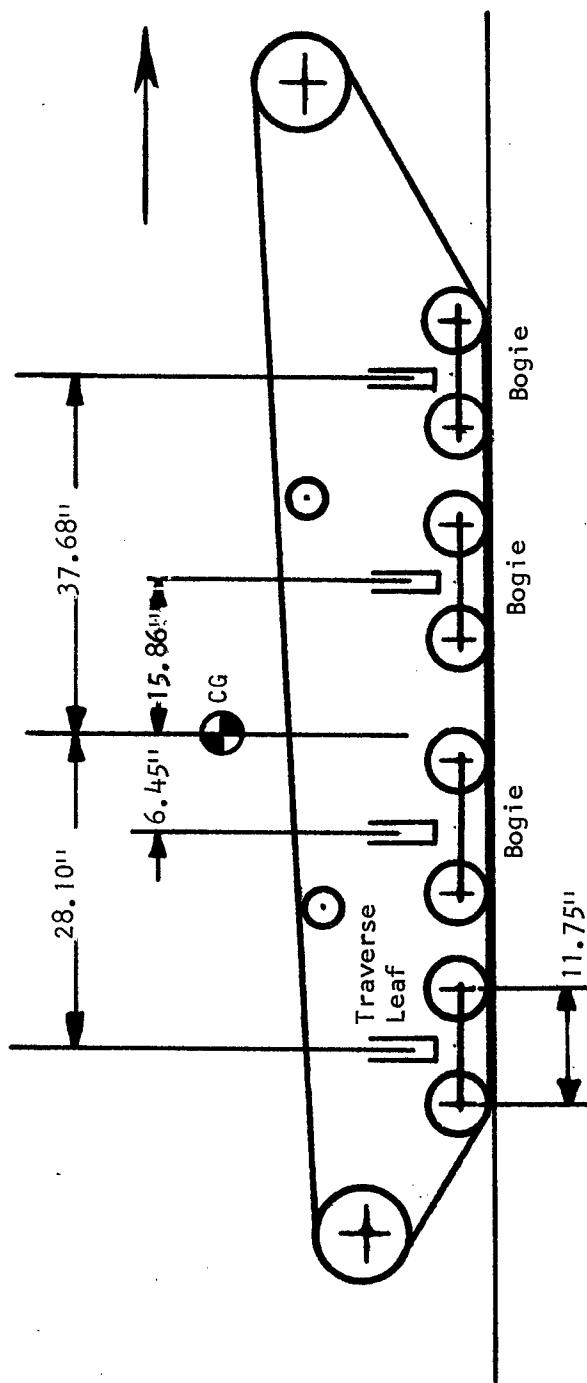


Fig. 10
WEASEL ROADWHEEL TO CG DIMENSIONS

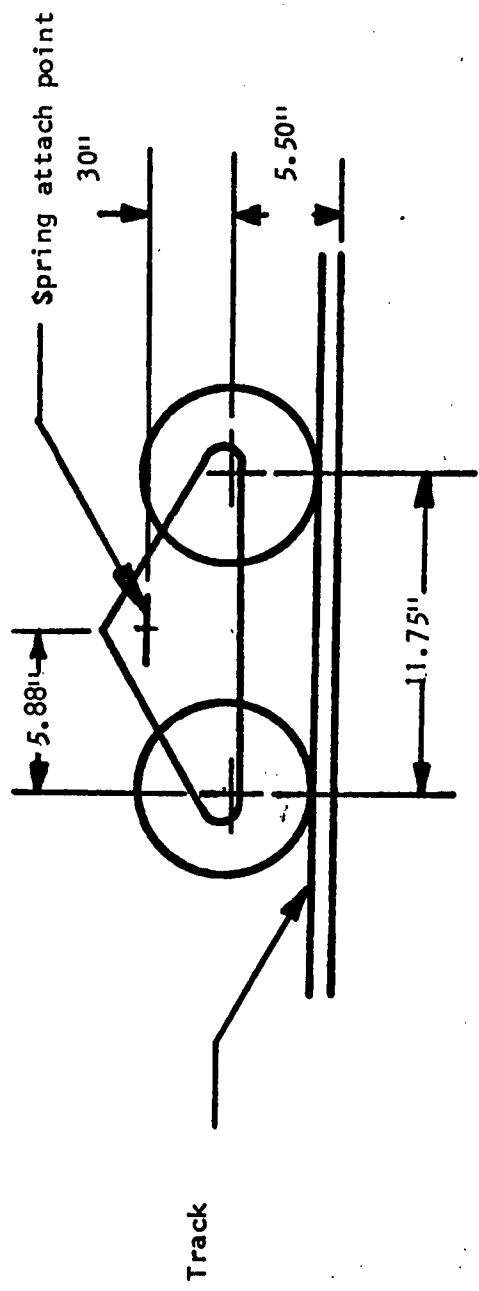


Fig. 11

BOGIE DETAILS

K-E 10 X 10 TO $\frac{1}{2}$ INCH 461323
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.

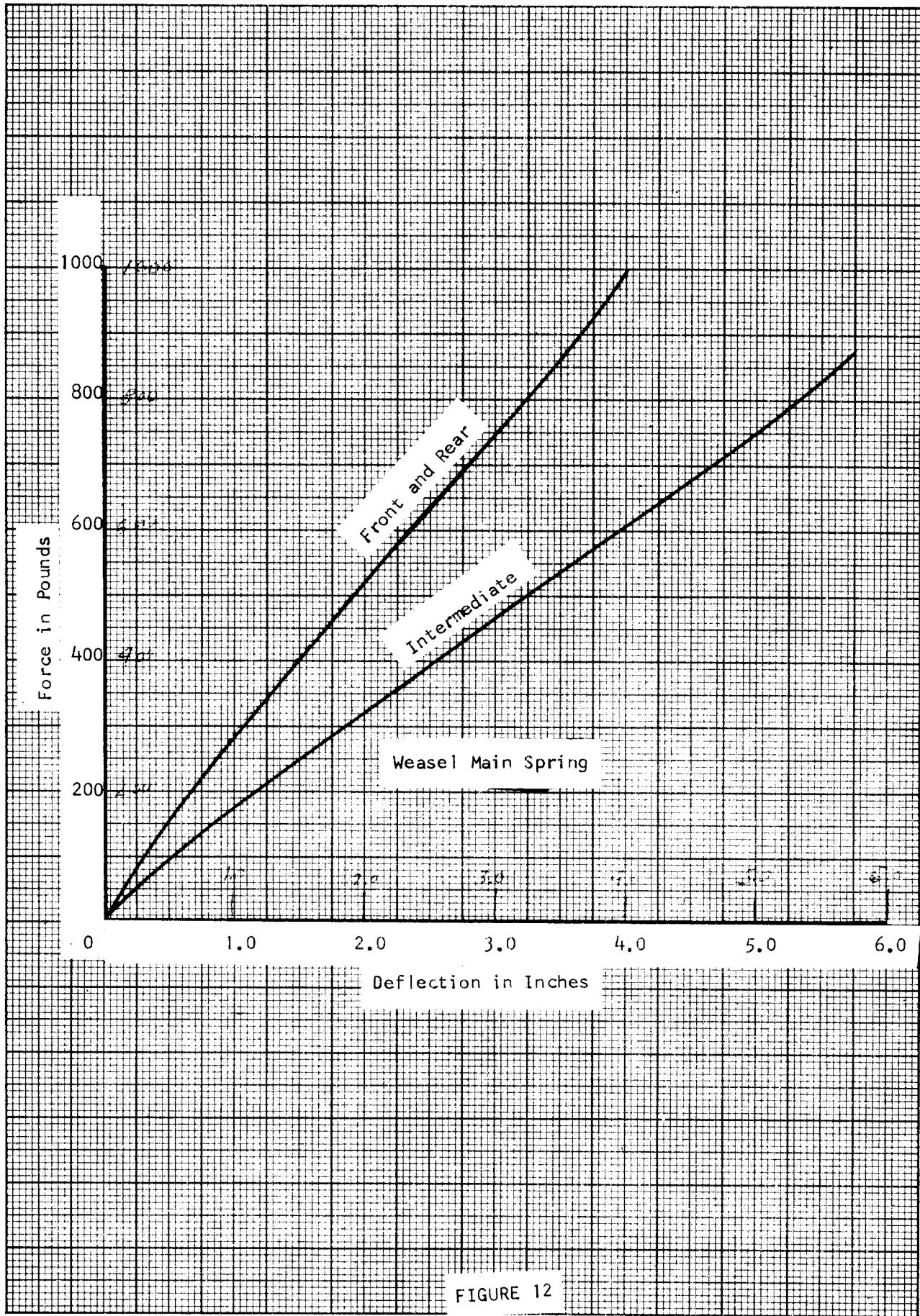
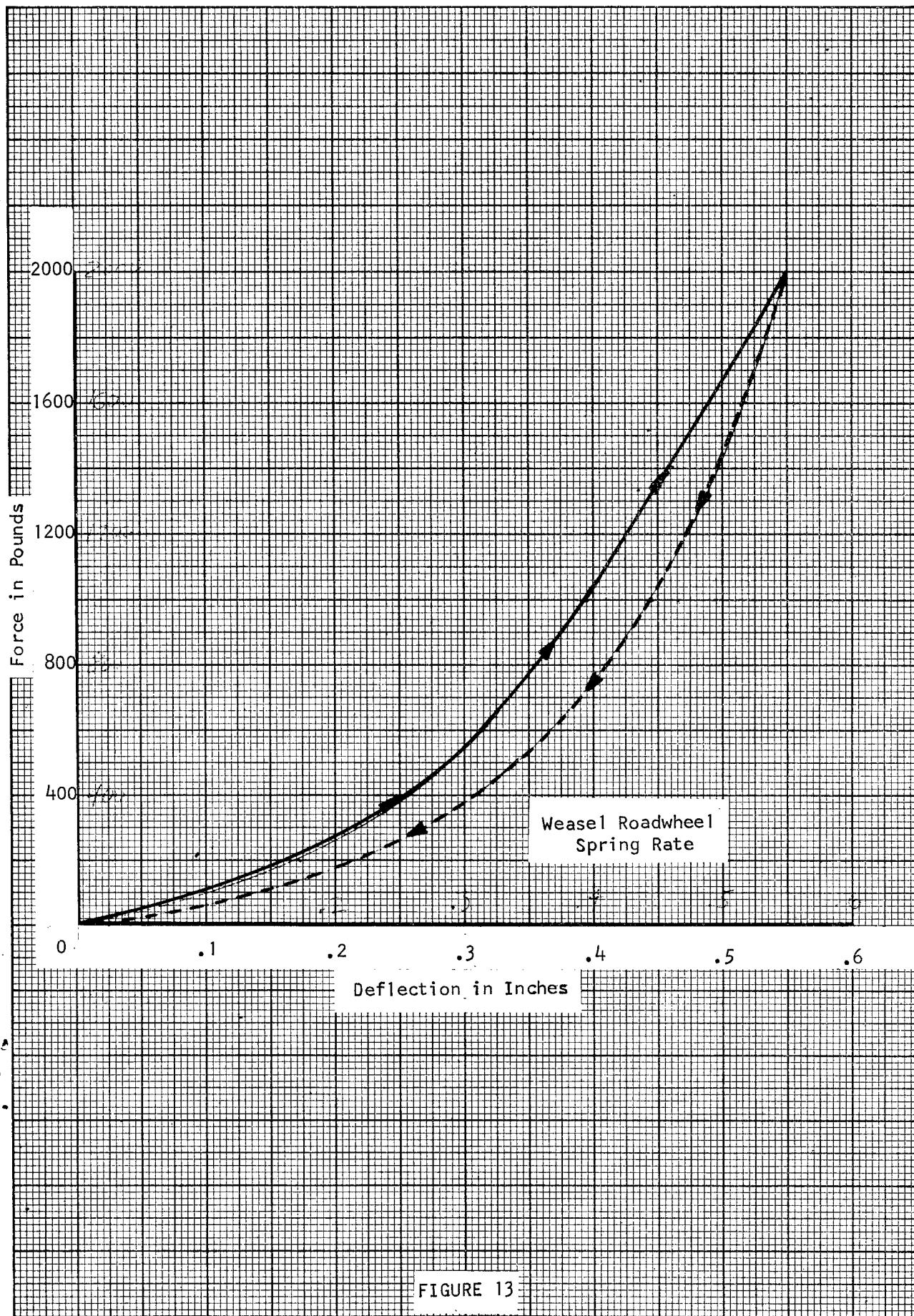


FIGURE 12



POLECAT

POLECAT

Total Weight	Front Unit	5982 Lbs.
	Rear Unit	5407 Lbs.
Sprung Weight	Front Unit	5400 Lbs.
	Rear Unit	4925 Lbs.
Unsprung Weight	Front Unit	582 Lbs.
	Rear Unit	482 Lbs.
Sprung Pitch Moment of Inertia	Front Unit	4300 Slug-Ft ²
	Rear Unit	3865 Slug-Ft ²
Distance from Ground to Center of Gravity		
	Front Unit	24 Inches
	Rear Unit	28 Inches
Shock Absorbers		Data Not Available
Assume Vertical Damping Ratio of .3, both Units		
Roadwheel Damping: Assume Damping Ratio of .1, both units		
Vehicle Dimensions: See Figures 14, 15, and 16.		
Spring Rates: See Figures 17, 18, 19, and 20.		

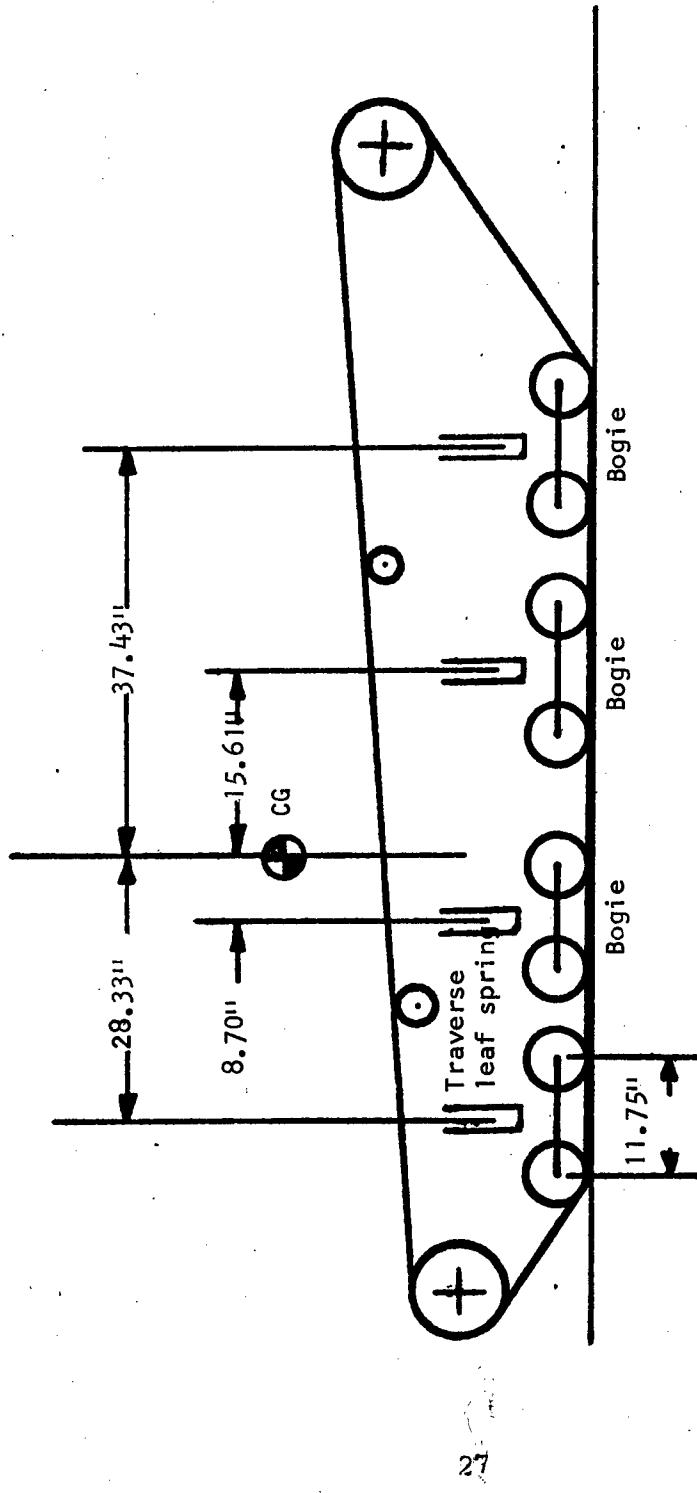


Fig. 14

POLECAT POWER UNIT ROADWHEEL TO CG DIMENSIONS

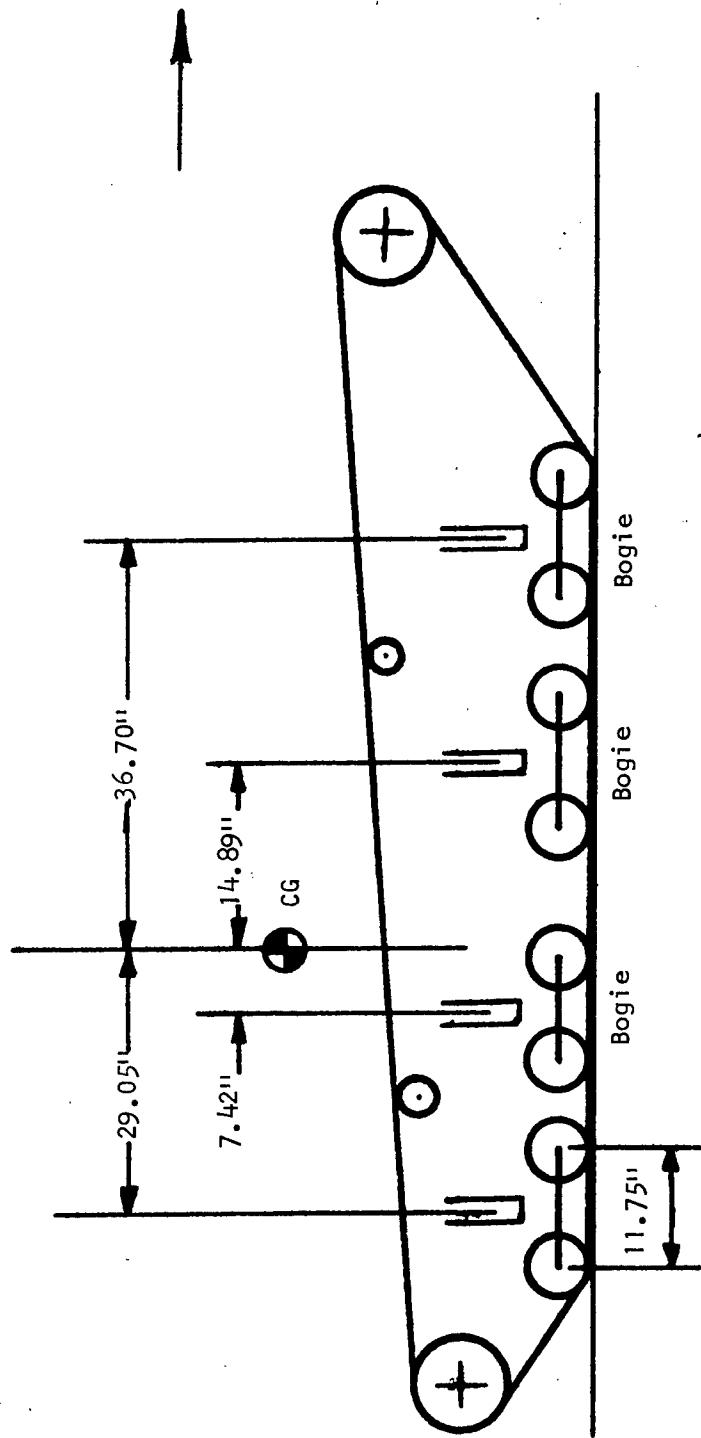


Fig. 15
POLECAT TRAILER UNIT ROADWHEEL TO CG DIMENSIONS

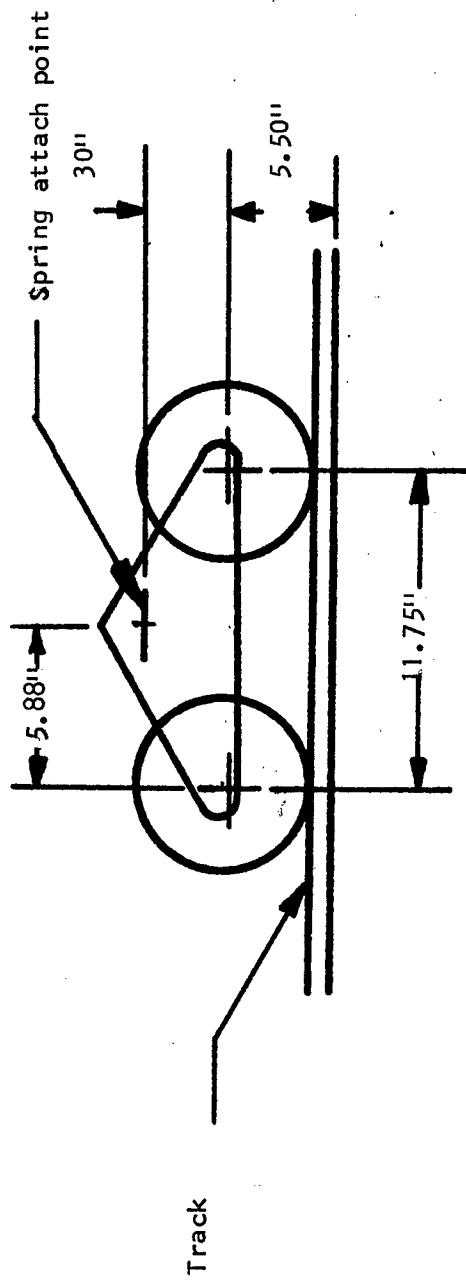
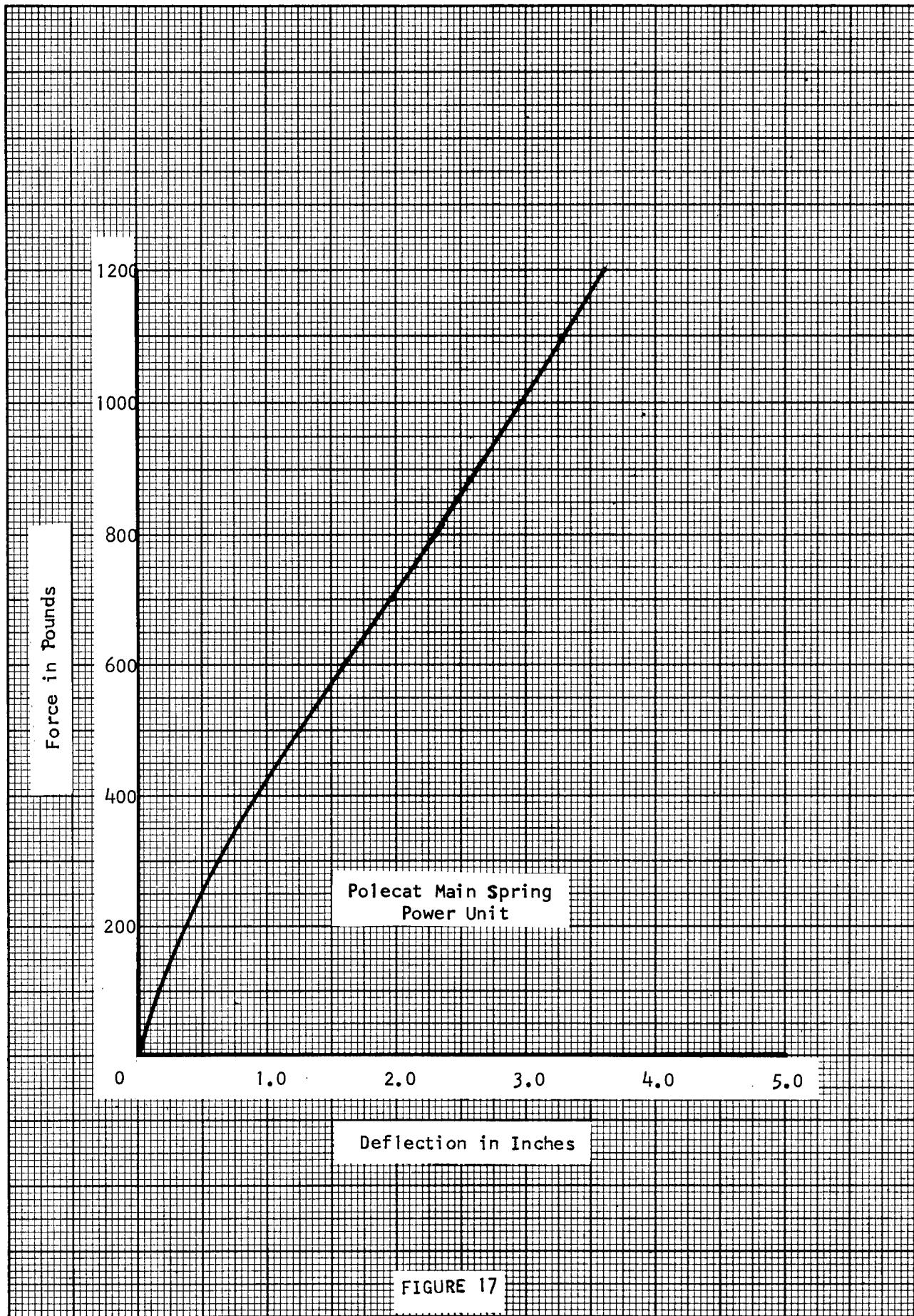
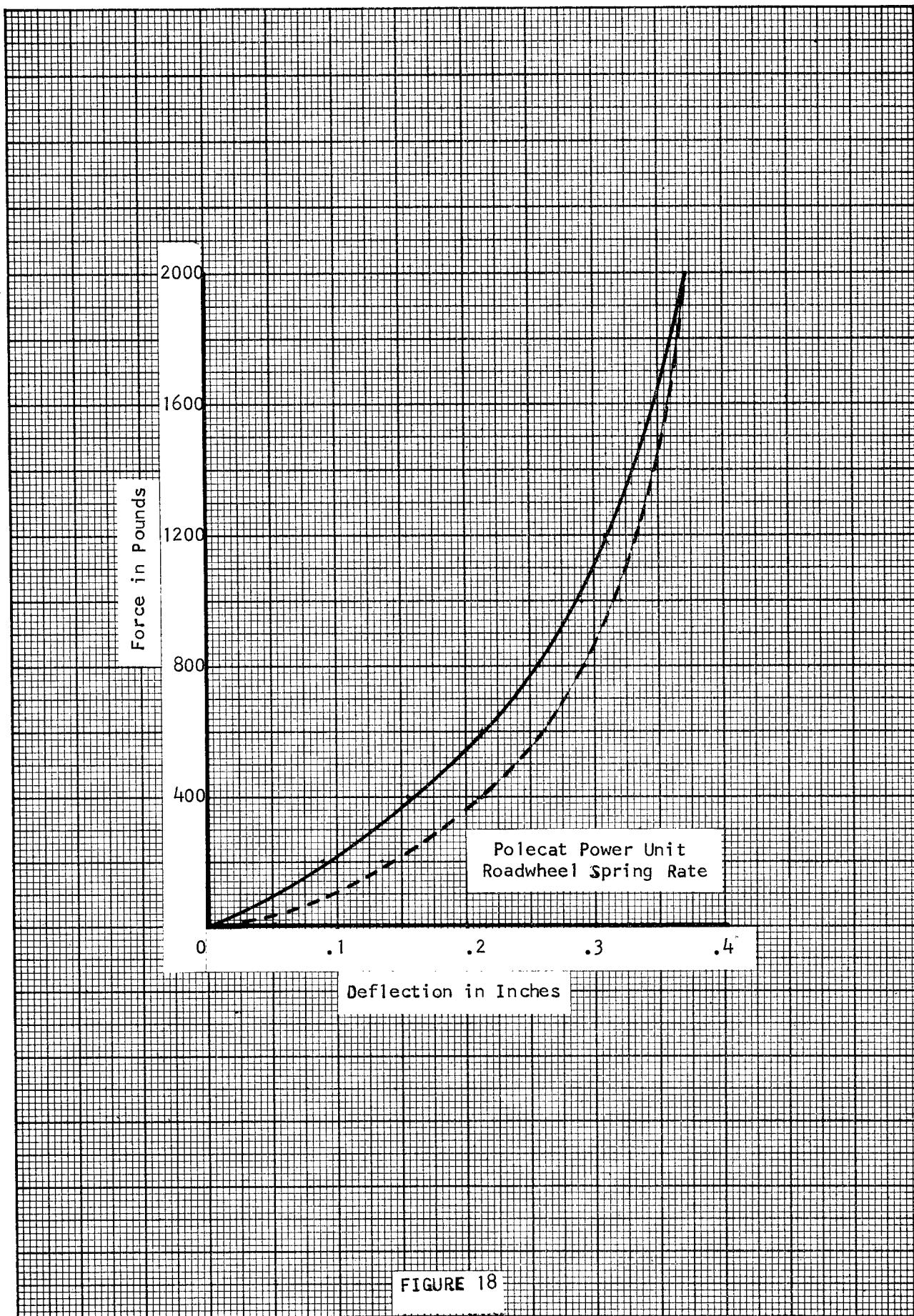
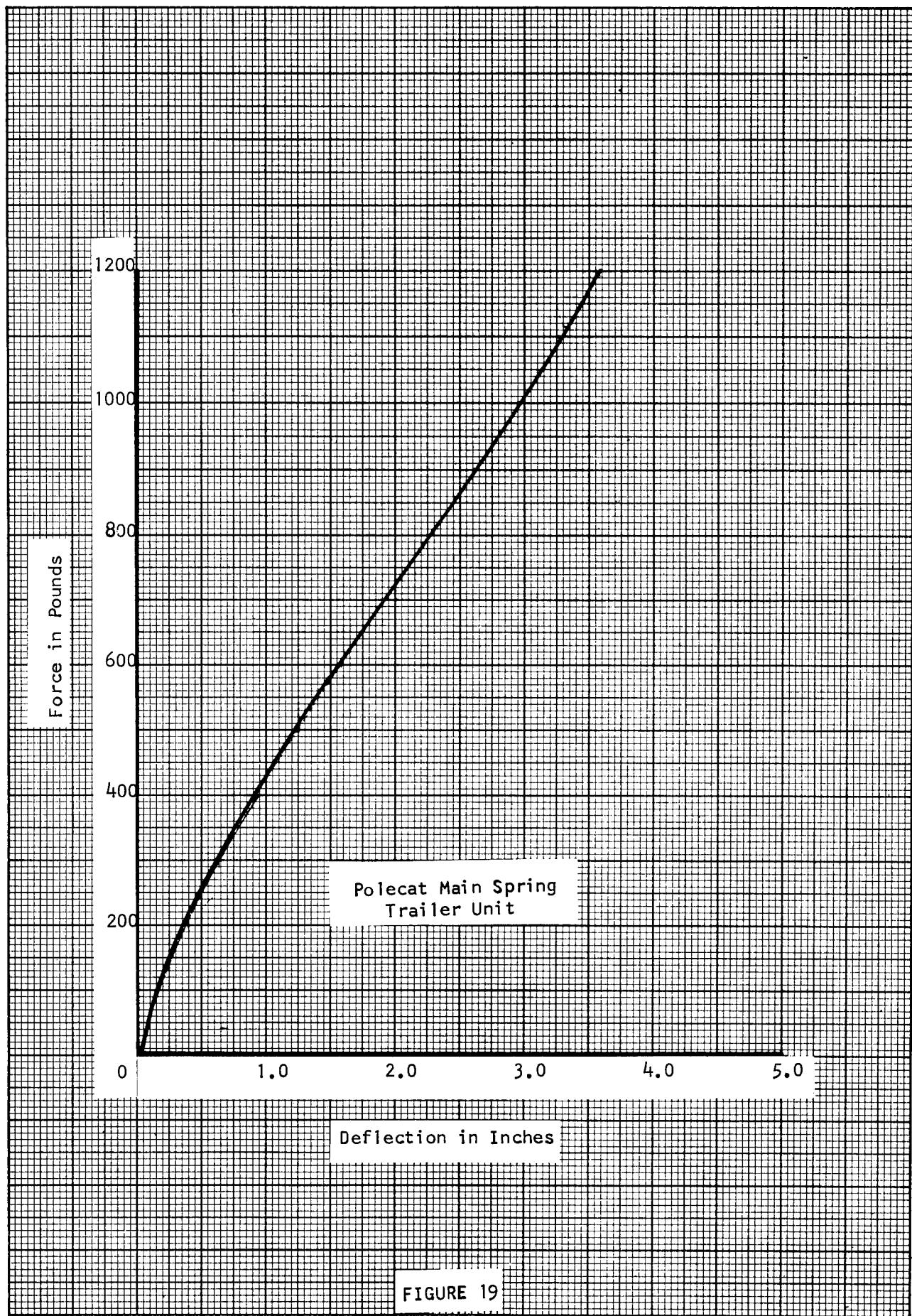


Fig. 16
BOGIE DETAILS

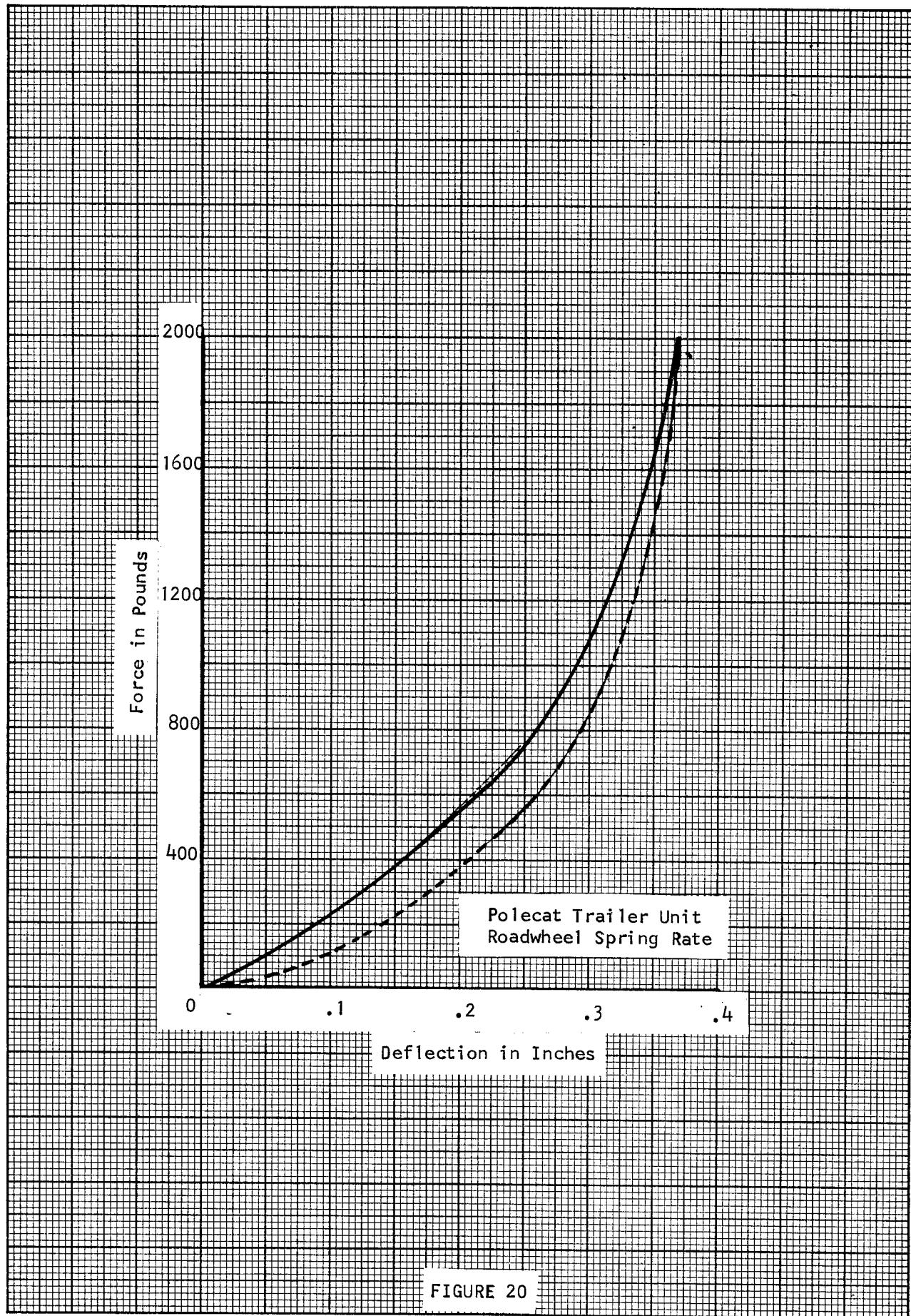


K+E 10 X 10 TO 1/2 INCH 46 1323
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.





K₄ 10 X 10 TO 1/2 INCH 46 1323
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.



TRACTOR

TRACTOR

Total Weight 12,764 Lbs.
Pitch Moment of Inertia 11,500 Slug-Ft²
Distance from Ground to Center of Gravity 22 Inches
Spring Rates per Wheel, estimated as 525,937 Lbs/Ft.
Vehicle Dimensions, see Figure 21.

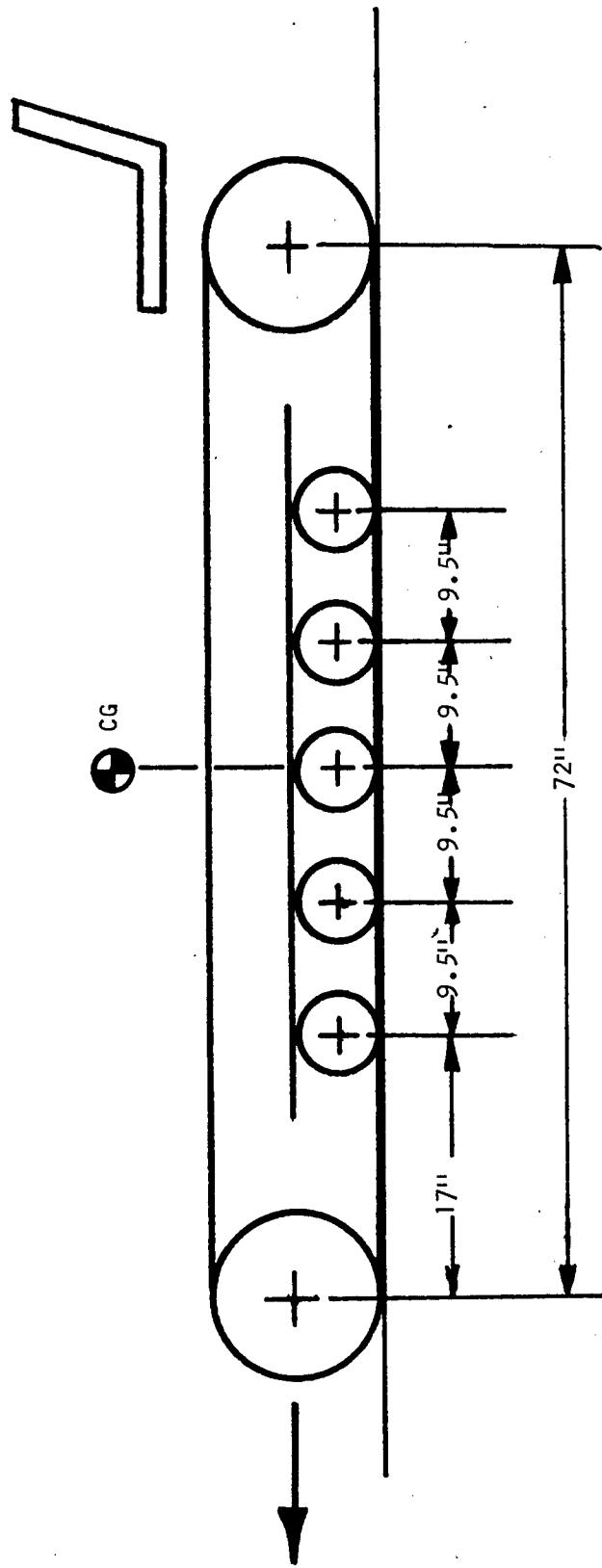


Fig. 21
TRACTOR ROADWHEEL TO CG DIMENSIONS

APPENDIX B
Terrain Profile Data

NUMERICAL PROFILE OF 600 FOOT HARD MEADOW

(Course Number I, All elevations taken above lowest point from East to West)

<u>Distance</u>	<u>North Track Elevation</u>	<u>South Track Elevation</u>	<u>Distance</u>	<u>North Track Elevation</u>	<u>South Track Elevation</u>
0	5.46	5.25	31	5.34	5.17
1	5.37	5.31	32	5.16	5.17
2	5.30	5.39	33	5.11	5.11
3	5.37	5.44	34	5.06	5.15
4	5.37	5.41	35	5.12	5.23
5	5.37	5.37	36	5.30	5.34
6	5.38	5.33	37	5.42	5.44
7	5.37	5.35	38	5.42	5.51
8	5.39	5.40	39	5.51	5.45
9	5.37	5.38	40	5.55	5.42
10	5.47	5.39	41	5.55	5.38
11	5.48	5.44	42	5.46	5.33
12	5.48	5.50	43	5.23	5.29
13	5.58	5.51	44	5.06	5.26
14	5.58	5.48	45	4.92	5.20
15	5.57	5.34	46	5.03	5.16
16	5.66	5.32	47	5.16	5.01
17	5.69	5.35	48	5.15	4.85
18	5.68	5.36	49	5.15	4.76
19	5.59	5.43	50	5.11	4.73
20	5.44	5.43	51	4.94	4.78
21	5.37	5.37	52	4.90	4.94
22	5.24	5.27	53	4.92	5.04
23	5.26	5.16	54	5.08	5.22
24	5.36	5.25	55	5.14	5.29
25	5.34	5.27	56	5.17	5.34
26	5.31	5.28	57	5.21	5.32
27	5.25	5.33	58	5.26	5.30
28	5.29	5.37	59	5.27	5.28
29	5.29	5.29	60	5.28	5.26
30	5.37	5.21	61	5.28	5.24

<u>Distance</u>	<u>North Track Elevation</u>	<u>South Track Elevation</u>	<u>Distance</u>	<u>North Track Elevation</u>	<u>South Track Elevation</u>
62	5.27	5.14	97	4.95	5.09
63	5.20	5.05	98	4.91	5.06
64	5.27	5.02	99	4.89	4.99
65	5.27	4.95	100	4.85	4.97
66	5.16	4.93	101	4.86	4.94
67	5.13	4.98	102	4.87	4.92
68	5.12	4.98	103	4.90	4.93
69	5.11	4.98	104	4.90	4.95
70	5.11	4.95	105	4.95	4.97
71	5.10	4.91	106	5.01	4.99
72	5.07	4.96	107	4.99	4.98
73	4.99	5.01	108	4.98	4.97
74	4.94	5.06	109	5.00	4.85
75	4.90	5.04	110	4.94	4.81
76	4.87	5.04	111	4.83	4.76
77	4.85	4.97	112	4.79	4.77
78	4.83	4.96	113	4.75	4.77
79	4.81	4.89	114	4.83	4.77
80	4.80	4.87	115	4.82	4.77
81	4.76	4.77	116	4.81	4.77
82	4.79	4.78	117	4.82	4.80
83	4.83	4.80	118	4.82	4.82
84	4.86	4.79	119	4.84	4.85
85	4.86	4.82	120	4.85	4.89
86	4.86	4.89	121	4.91	4.93
87	4.86	4.87	122	4.97	4.96
88	4.86	4.85	123	4.97	4.99
89	4.82	4.91	124	4.94	4.99
90	4.88	4.95	125	4.91	4.99
91	4.95	4.99	126	4.88	4.98
92	4.94	4.89	127	4.84	4.97
93	4.91	5.02	128	4.82	4.89
94	4.98	5.12	129	4.85	4.87
95	4.98	5.06	130	4.88	4.86
96	4.98	5.13	131	4.98	4.87

<u>Distance</u>	<u>North Track Elevation</u>	<u>South Track Elevation</u>	<u>Distance</u>	<u>North Track Elevation</u>	<u>South Track Elevation</u>
132	5.02	4.81	167	4.62	4.74
133	5.05	4.80	168	4.59	4.62
134	4.99	4.76	169	4.58	4.56
135	4.95	4.75	170	4.53	4.47
136	4.90	4.73	171	4.46	4.50
137	4.90	4.76	172	4.42	4.64
138	4.97	4.74	173	4.41	4.53
139	5.00	4.74	174	4.40	4.50
140	4.93	4.74	175	4.39	4.47
141	4.87	4.71	176	4.39	4.54
142	4.76	4.66	177	4.49	4.51
143	4.69	4.68	178	4.49	4.45
144	4.62	4.64	179	4.34	4.36
145	4.65	4.65	180	4.47	4.35
146	4.66	4.65	181	4.33	4.33
147	4.67	4.66	182	4.16	4.28
148	4.76	4.69	183	4.29	4.27
149	4.78	4.64	184	4.25	4.23
150	4.81	4.59	185	4.21	4.18
151	4.86	4.68	186	4.19	4.15
152	4.87	4.71	187	4.21	4.30
153	4.88	4.74	188	4.21	4.31
154	4.88	4.78	189	4.24	4.15
155	4.89	4.81	190	4.25	4.06
156	4.95	4.76	191	4.22	4.10
157	4.93	4.76	192	4.21	4.10
158	4.91	4.77	193	4.20	4.11
159	4.91	4.72	194	4.19	4.11
160	4.90	4.87	195	4.18	4.11
161	4.94	4.96	196	4.17	4.11
162	4.94	5.04	197	4.16	4.11
163	4.86	5.07	198	4.15	4.10
164	4.77	5.03	199	4.13	4.10
165	4.67	4.97	200	4.12	4.10
166	4.65	4.90	201	4.13	3.98

<u>Distance</u>	<u>North Track Elevation</u>	<u>South Track Elevation</u>	<u>Distance</u>	<u>North Track Elevation</u>	<u>South Track Elevation</u>
202	4.05	3.95	237	4.10	4.29
203	3.97	3.92	238	4.05	4.33
204	4.10	3.96	239	3.80	4.29
205	4.11	3.99	240	3.84	4.26
206	4.13	4.02	241	3.85	4.16
207	4.14	4.05	242	3.87	4.04
208	4.16	4.08	243	3.94	4.00
209	4.17	4.11	244	4.00	4.07
210	4.16	4.11	245	4.07	4.19
211	4.15	4.12	246	4.13	4.17
212	4.14	4.12	247	4.17	4.18
213	4.09	4.12	248	4.28	4.11
214	4.03	4.12	249	4.24	4.02
215	3.97	4.10	250	4.15	3.95
216	3.92	4.09	251	3.99	3.64
217	3.91	4.00	252	3.80	3.40
218	3.91	3.91	253	3.57	3.29
219	3.93	3.93	254	3.55	3.30
220	3.95	3.96	255	3.61	3.35
221	4.02	3.98	256	3.69	3.41
222	4.09	3.99	257	3.68	3.45
223	4.08	3.04	258	3.78	3.50
224	4.08	3.08	259	3.78	3.51
225	3.97	4.07	260	3.78	3.52
226	3.99	3.97	261	3.77	3.54
227	3.96	3.96	262	3.74	3.58
228	3.93	3.94	263	3.71	3.64
229	3.94	3.89	264	3.61	3.60
230	3.92	4.00	265	3.59	3.43
231	3.94	4.20	266	3.54	3.34
232	4.01	4.34	267	3.51	3.20
233	4.05	4.33	268	3.44	3.23
234	4.10	4.35	269	3.38	3.21
235	4.19	4.27	270	3.32	3.21
236	4.16	4.25	271	3.20	3.15

<u>Distance</u>	<u>North Track Elevation</u>	<u>South Track Elevation</u>	<u>Distance</u>	<u>North Track Elevation</u>	<u>South Track Elevation</u>
272	3.18	3.08	307	2.24	2.00
273	3.20	3.04	308	2.11	1.92
274	3.24	3.04	309	2.32	1.87
275	3.19	3.02	310	2.24	1.81
276	3.11	2.94	311	2.14	1.83
277	3.08	2.85	312	2.05	1.78
278	2.98	2.86	313	1.90	1.78
279	2.90	2.86	314	1.75	1.85
280	2.98	2.89	315	1.62	2.07
281	2.87	2.81	316	1.69	2.08
282	2.86	2.85	317	1.73	1.95
283	2.84	2.89	318	1.73	1.88
284	2.83	2.73	319	1.73	1.91
285	2.76	2.70	320	1.74	1.85
286	2.69	2.67	321	1.78	1.80
287	2.66	2.67	322	1.83	1.90
288	2.63	2.68	323	1.88	1.82
289	2.70	2.58	324	1.91	1.62
290	2.73	2.55	325	1.91	1.56
291	2.75	2.59	326	1.84	1.64
292	2.84	2.58	327	1.73	1.56
293	2.86	2.53	328	1.63	1.46
294	2.84	2.46	329	1.52	1.50
295	2.82	2.56	330	1.44	1.44
296	2.86	2.59	331	1.46	1.47
297	2.80	2.53	332	1.48	1.51
298	2.71	2.40	333	1.46	1.40
299	2.59	2.37	334	1.52	1.33
300	2.52	2.28	335	1.67	1.27
301	2.40	2.25	336	1.51	1.22
302	2.37	2.18	337	1.44	1.23
303	2.34	2.15	338	1.35	1.11
304	2.30	2.13	339	1.26	1.14
305	2.31	2.14	340	1.19	1.07
306	2.32	2.09	341	1.11	1.18

<u>Distance</u>	<u>North Track Elevation</u>	<u>South Track Elevation</u>	<u>Distance</u>	<u>North Track Elevation</u>	<u>South Track Elevation</u>
342	.1.03	1.19	377	.45	.51
343	.96	1.12	378	.44	.48
344	1.16	1.05	379	.40	.38
345	1.25	1.10	380	.38	.54
346	1.26	1.09	381	.35	.54
347	1.15	1.01	382	.39	.51
348	1.05	1.01	383	.43	.48
349	1.00	1.08	384	.44	.50
350	1.06	1.08	385	.46	.53
351	1.03	1.04	386	.48	.55
352	1.01	.99	387	.50	.58
353	.96	.93	388	.46	.55
354	.90	.88	389	.42	.52
355	1.04	.81	390	.46	.39
356	1.05	.72	391	.47	.43
357	.93	.67	392	.49	.47
358	.91	.60	393	.51	.52
359	.89	.57	394	.51	.51
360	.88	.55	395	.51	.50
361	.90	.58	396	.51	.50
362	.86	.60	397	.51	.49
363	.76	.56	398	.51	.48
364	.77	.58	399	.54	.51
365	.59	.53	400	.58	.55
366	.58	.54	401	.60	.55
367	.56	.55	402	.63	.56
368	.54	.56	403	.77	.60
369	.53	.51	404	.72	.63
370	.52	.66	405	.68	.65
371	.50	.63	406	.54	.64
372	.48	.61	407	.61	.69
373	.46	.59	408	.60	.70
374	.47	.57	409	.60	.71
375	.48	.56	410	.59	.72
376	.47	.54	411	.56	.72

<u>Distance</u>	<u>North Track Elevation</u>	<u>South Track Elevation</u>	<u>Distance</u>	<u>North Track Elevation</u>	<u>South Track Elevation</u>
412	.53	.72	447	.35	.38
413	.50	.71	448	.35	.38
414	.48	.71	449	.32	.39
415	.48	.71	450	.28	.40
416	.49	.70	451	.24	.41
417	.49	.70	452	.20	.42
418	.49	.70	453	.22	.54
419	.51	.77	454	.22	.56
420	.50	.76	455	.22	.58
421	.50	.76	456	.17	.44
422	.49	.75	457	.16	.53
423	.47	.66	458	.17	.55
424	.43	.65	459	.18	.58
425	.32	.63	460	.17	.57
426	.33	.61	461	.16	.55
427	.33	.58	462	.15	.53
428	.34	.55	463	.14	.51
429	.35	.53	464	.13	.49
430	.36	.55	465	.12	.53
431	.36	.55	466	.10	.56
432	.36	.55	467	.10	.51
433	.30	.53	468	.10	.46
434	.23	.51	469	.11	.43
435	.22	.50	470	.13	.39
436	.21	.49	471	.15	.35
437	.22	.47	472	.17	.32
438	.23	.45	473	.18	.28
439	.24	.42	474	.19	.29
440	.30	.40	475	.20	.30
441	.37	.38	476	.20	.30
442	.37	.38	477	.21	.31
443	.36	.38	478	.22	.32
444	.36	.38	479	.22	.33
445	.36	.38	480	.22	.33
446	.35	.38	481	.23	.34

<u>Distance</u>	<u>North Track Elevation</u>	<u>South Track Elevation</u>	<u>Distance</u>	<u>North Track Elevation</u>	<u>South Track Elevation</u>
482	.23	.34	517	.60	.64
483	.23	.35	518	.50	.43
484	.24	.37	519	.47	.24
485	.26	.40	520	.47	.21
486	.27	.43	521	.46	.29
487	.28	.45	522	.42	.33
488	.30	.47	523	.38	.36
489	.32	.48	524	.32	.43
490	.33	.49	525	.27	.39
491	.35	.50	526	.27	.29
492	.36	.49	527	.33	.32
493	.37	.48	528	.47	.48
494	.38	.48	529	.42	.53
495	.39	.47	530	.58	.63
496	.33	.58	531	.63	.50
497	.33	.66	532	.55	.41
498	.30	.59	533	.61	.35
499	.42	.60	534	.62	.31
500	.59	.48	535	.53	.38
501	.72	.56	536	.43	.29
502	.86	.58	537	.46	.41
503	.82	.47	538	.35	.43
504	.77	.49	539	.35	.30
505	.52	.53	540	.35	.24
506	.39	.65	541	.34	.35
507	.41	.50	542	.32	.52
508	.47	.48	543	.37	.35
509	.56	.53	544	.21	.34
510	.64	.58	545	.17	.24
511	.59	.62	546	.12	.05
512	.55	.62	547	.09	.09
513	.68	.72	548	.15	.14
514	.78	.77	549	.20	.17
515	.80	.80	550	.14	.26
516	.73	.77	551	.08	.26

<u>Distance</u>	<u>North Track Elevation</u>	<u>South Track Elevation</u>	<u>Distance</u>	<u>North Track Elevation</u>	<u>South Track Elevation</u>
552	.09	.27	587	.25	.60
553	.10	.27	588	.22	.61
554	.17	.28	589	.22	.63
555	.27	.26	590	.22	.64
556	.38	.28	591	.22	.65
557	.31	.22	592	.22	.66
558	.17	.22	593	.22	.68
559	.06	.15	594	.24	.78
560	.00	.07	595	.25	.82
561	.00	.08	596	.29	.77
562	.06	.12	597	.30	.71
563	.00	.15	598	.31	.65
564	.12	.13	599	.31	.65
565	.00	.12	600	.31	.65
566	.00	.20			
567	.04	.32			
568	.20	.47			
569	.31	.45			
570	.35	.60			
571	.35	.60			
572	.30	.58			
573	.35	.41			
574	.32	.56			
575	.33	.68			
576	.32	.65			
577	.28	.56			
578	.28	.49			
579	.38	.49			
580	.45	.50			
581	.45	.55			
582	.45	.60			
583	.40	.55			
584	.35	.51			
585	.31	.54			
586	.28	.58			